EVALUATION AND COMPARISON OF SHEAR BOND STRENGTH OF GLASS IONOMER, RESIN MODIFIED GLASS IONOMER AND COMPOSITE RESIN IN PRIMARY MOLARS

- AN IN VITRO STUDY

Dr. SONU BOSE, (III MDS),

DEPARTMENT OF PEDODONTICS

SAVEETHA DENTAL COLLEGE AND HOSPITALS

INTRODUCTION

Pediatric restorative dentistry is a dynamic combination of ever improving materials and tried – and – trued techniques. The preservation of the primary dentition until it's normal, anticipated exfoliation is the main aim of the pediatric restorative materials.[1]

Shear bond strength of a restorative material is done to evaluate it's adhesive capacity. As a result of a shear stress application, one material should resist sliding past another.[2]

Materials such as Glass Ionomers, Resin Modified Glass Ionomers, and improved Resin- based Composites have been developed that are having a profound impact on the restoration of primary teeth[1].

Composite resins and Glass Ionomers are increasingly becoming the materials of choice for restoring primary teeth.[3]

Glass Ionomer Cements (GICs) are a product of an acid base reaction between a basic fluoro-alumino-silicate glass powder and polycarboxylic acid in the presence of water.[4]

Glass Ionomer Cements possess several beneficial properties, including chemical adhesion to tooth structures and release of fluoride ions.[5]

Compared with Composite Resins, the Glass Ionomers are relatively unaesthetic and have poor physical properties, including low flexural strength and fracture toughness.[6]

The Resin Modified Glass Ionomer Cement is defined as a material that undergoes both a polymerization reaction and an acid – base reaction. They are more esthetic and less water sensitive than conventional glass ionomers. [7]

Many studies have been done on shear bond strength of materials such as composite resin, glass ionomer and resin modified glass ionomers in permanent teeth, but very few or no studies were done to compare the shear bond strength of these restorative materials in primary molars.

The purpose of this study was to evaluate and compare the shear bond strength of Glass Ionomer Cement (Fuji IX GP), Resin Modified Glass Ionomer Cement (Fuji II LC) and Composite Resin (Filtek Z-250).

AIMS AND OBJECTIVES

The aim of the study was to evaluate and compare the shear bond strength of Glass Ionomer (Fuji IX), Resin Modified Glass Ionomer (Fuji II LC), and Composite Resin (Filtek Z-250).

REVIEW OF LITERATURE

***Selvig KA (1968)*[8]** reported that, since the penetration of acids occurs primarily along the tubules it could be possible that a larger number of tubules with a larger diameter could result in a deeper penetration of the acidic conditioner and therefore stronger demineralization.

***Nelson GV, Osborne JW, Gale EN (1980)*[9]** in a three year study, believed that composite resin restoration would be well indicated when the projected life span of the tooth is 3 years.

***Miller J (1981)*[10]** reported the role of the micro canals or giant dentin tubules that have been observed in dentin of primary teeth in the bonding process is unclear but they may also contribute to an additional reduction in bond strength.

***Powis et al (1982)*[11]** found out that certain pretreatments of the dentin surface, particularly partial removal of the smear layer with polyacrylic acid, can improve bond strengths .

Pashley DH et al (1984)[12] reported that conditioning the dentin is fundamental to remove the smear layer, partially demineralize the intertubular dentin, and expose the collagen fibers to allow the establishment of a hybrid layer.

A.W. Walls, J.F. McCabe, J.J. Murray (1988)[5] evaluated the setting characteristics of a number of commercially available glass polyalkenoate cements, and reported that cements with high molecular weight polyakenoic acids set more rapidly and have greater mechanical strength than those with low – molecular weight acids and the heat generated during the reaction is dependent upon the quantity of glass dissolved from the surface of the glass particles which in turn will be influenced by the pH of the acids performing the dissolution.

Lyndon F, Cooper, Michael Myers (1988)[13] evaluated the shear bond strength of composite to dentinal surface that had received pretreatment with Co_2 laser irradiation. There was a increased bond in strength compared with unlased dentin. The laser pre-treatment of the dentin produced surface irregularities that were filled with the composite and the failures occurred within the dentin. This indicates the potential of laser irradiation of dentin to significantly increase composite / dentin bond strengths.

AM Diaz, Arnold, VD Williams (1990)[14] reviewed common substrates and testing conditions used in dentinal bond strength studies in vitro. The available literature supported the use of freshly extracted, hydrated human teeth for studies in vitro. No one testing condition has proven superior accuracy over the others.

Cook P A (1990)[15] compared the in-vivo bond strength of glass ionomer cement with a composite resin bonding agent. The result of this evaluation indicated that the bond strength of the glass ionomer was not nearly as good as that of the composite resin.

Fajen et al (1990)[16] evaluated the bond strengths of the glass ionomer cements against a composite resin in vitro, and found the bond strength of the glass ionomers to be significantly less.

Prati C et al (1991)[17] found that when the depth of demineralization of the intertubular dentin is excessive, the collagen fibers collapse and form a dense layer that may not be fully impregnated by the primer and adhesive resin. In these circumstances, the mineral matrix removed is not replaced fully by the primer, leaving a weaker area at the bottom of the hybrid layer, which potentially becomes a pathway for microleakage or a site for bonding failure.

Rezk- Lega et al (1991)[18] conducted an in vitro study of glass ionomer versus composite resin bonding agents and concluded that glass ionomer cements have significantly less bond strength than composite resin.

Rueggeberg (1991)[19] demonstrated that there are myriad factors than can significantly affect the result of adhesion testing tooth tissues. Although there is no one methodology for selection criteria or surface preparation of the substrate for adhesion testing, the need for standardized methods of analysis as well as data interpretation is of utmost urgency.

Salama F S, Tao L (1991)[20] has reported that the bond strengths of composite resins to the dentin surface is lower in primary teeth than the permanent teeth.

Cooley RL, Barkmeier WW (1991)[21] reported lower bond strength of resin modified glass ionomers than those typically reported for composite resin bonded to dentin with current generation adhesives systems.

Bordin-Aykroyd S et al (1992)[22], stated that there are physiological and morphological differences between the primary and permanent dentitions. These differences in primary teeth include less enamel, pulpal anatomy that closely follows the dentin enamel junction, and differences in tubular dentin.

John Kanca III (1992)[23] evaluated the ability of a dentin – enamel bonding system to bond to wet, as well as to dry dentinal using 10% and 37% phosphoric acid surface conditioning. The wet dentinal surface exhibited significantly higher bond strengths than did the dry surfaces. It was suggested that, because of unique behaviour of the resin – Primer mixture, the dentinal surface is adapted to it much more thoroughly and intimately when the surface is wet.

Wayne W, Barkmeier, Robert L Cooley (1992)[24] evaluated the dentin adhesive systems. Earlier generation dentin bonding systems did not yield high bond strength strengths in the laboratory or prevent marginal microleakage. Newer generation adhesive systems generally use a dentin conditioner to modify or remove the smear layer and a subsequent application of an adhesive resin bonding agent. Laboratory evaluations of newer systems have shown bond strengths that approach or actually exceed that of etched enamel resin bonding.

B Van Meerbeek, P Lambrechts (1992)[25] reviewed factors affecting adhesion to mineralized tissues, the physicochemical structure of the adherents, the inherent properties of composite restorative materials, along with the postulated bonding mechanisms of current adhesive systems.

DH Pashley, JA Horner (1992)[26] reported that it is desirable to reduce the acid concentration and/or application time to the minimum required to obtain maximum bond strengths and minimum microleakage. The pulpal effects of acid conditioners seem to be minimal if the subsequently placed bonding agents and resin composites truly seal dentin.

Harold R, Stanley (1992)[27] stated that since only the dentin surface needs to be changed slightly, and not its depth.

Attention can be paid to techniques that merely remove or modify the smear layer without removing the smear plugs and adjacent sclerotic dentin, which permits the outflow of pulpal fluids. A technique that merely lets conditioning solution soak (passively) the dentin surface is adequate.

Triolo PT, Swift EJ (1992).[28] reported that in most situations, bonding agents demonstrated less shear bond strength in primary than permanent tooth dentin, however, many dentin bonding agents has the potential to equal or exceed the bond strength to enamel in primary teeth.

Bordin- Aykroyd, Sefton J & Davies E H (1992)[29] has indicated that bond strengths to primary teeth may be somewhat lower.

John Kanca III (1992)[23] reported that Glass ionomer cements, including the resin modified restoratives, are water-based materials. Presumably therefore, they will bond better to dentin surfaces that are not completely hydrated, as is the case with the newer hydrophilic dentin bonding system. In this study, dentin was blotted dry, not desiccated with air after dentin conditioning.

Lin, McIntyre, Davidson (1992)[30] used analytical techniques to identify 3 factors that are involved in the adhesion of a light activated glass ionomer liner to dentin. First, penetration of the glass ionomer through the smear layer and into the dentinal tubules is greater than that observed with chemical cure glass ionomer, so there is more mechanical interlocking with the substrate. Also, the adsorption of a thin strong polymer layer on dentin may be more rapid with the light cured material. Finally, the study demonstrated that ion exchanges occur between glass ionomer and dentin at their interface.

Gwinnett AJ, Garcia – Godoy (1992)[31] have shown that the etchant should be applied for 20 – 30 seconds to both the enamel and dentin. They found that there was no statistically significant difference between the bond strengths of resin placed to enamel etched for 20 or 60 seconds.

Burgess and Burkett (1993)[32] reported light activated (i.e. resin modified) glass ionomer liners to have superior bond strength than those of conventional glass ionomers, generally in the range of 6-12 MPa.

Heymann & Bayne (1993)[33] suggested traditional dentinal adhesive research has focused on material factors than important clinical co-variables. Many other factors are as important as the adhesive material itself. Dentin factors, tooth factors and patient factors, as well as material factors, must be jointly understood and related in the overall "bonding equation".

Leinfeider (1993)[34] stated that major progress has occurred in the area of dentin adhesives. The systems today are considerably better than those previously available in dentistry. In addition to their excellent bonding potential, these systems have been effective in isolating the odontoblastic processes and the pulp from the oral environment.

Eick, Robinson, Chappell (1993)[35] suggested an effective dentin – adhesive bond depends on several factors, including the wetting and penetration characteristics of the dentinal adhesive system and the reactivity of the treated dentinal surface. His study also showed that the structure of collagen in the demineralized dentin layer may influence the behaviour of the bond. Adhesive systems that did not completely denature the fibrous collagen and left inter woven, banded collagen in the demineralized layer, produced superior bond strengths.

Wilder et al (1994)[36] suggested that visibly moist dentin surfaces are the preferred substrate for bonding with these materials.

Elizabeth CHO, Hugh Kopel, Shane N. White (1995)[37] in their experiment studied if Resin-modified glass ionomer cement are sensitive to moisture than conventional glass ionomer cement to investigate the effects of barrier coating. This study showed that resin modified glass ionomer cement were less moisture sensitive than conventional glass ionomer cement suggesting resinous polymerization rather than ionomeric acid – base reaction.

E.J. Swift, M.A. Pawlus, M.A. Vargas (1995)[38] evaluated shear bond strength of resin – modified glass ionomer cement restorative materials to dentin with conventional glass ionomer cement restorative material. Results revealed a superior bond strength of resin modified glass ionomer cement which can be attributed due to penetration of light cure glass ionomer cement through the smear layer and into dentinal tubules than that observed with chemical cure, so there is more mechanical interlocking with the substrate and absorption of a thin strong polymer layer on dentin may be more rapid with the light cured material suggesting the seasons for better bond.

Nicholas Mazzeo, Norman Ott, Steven Hondrum (1995)[39] has reported that the bond between dentin bonding system and dentin is thought to be derived from micromechanical retention of the dentin bonding system to intertubular dentin, a chemical interaction of the bonding systems to the inorganic / organic components of dentin may also play a role.

Nor et al (1996)[40] reported that the hybrid layer produced in primary teeth was 25 – 30% thicker than in permanent teeth and concluded that primary dentin was more reactive to acidic conditioners.

William W. Brackett, Eugene F. Huget (1996)[41] evaluated shear bond strength of resin composite to three resin – modified glass ionomer cements (Fuji II LC, Vitremer, Photac FIL) and one conventional glass ionomer cement (ketac FIL) at two time intervals, immediately after setting and after aging of the cement for 5 months following phosphoric acid etching, maleic acid etching or no etching. The results showed for all the three resin – modified materials etching improved regardless of the age of the cement. For a chemically set material the same effects were observed, except when etching the recently set cement with maleic acid, as it was detrimental to adhesion because it was suspected that the organic acid was chemically similar to the polyacids of the cement to disrupt the long term set of cement surface.

M.G. Duncanson, JR Frank, J Miranda (1996)[42] reported the bond of currently available dentin bonding products to dentin is a relatively weak one when compared with the bond to acid-etched enamel. However products developed and research conducted to date, offer some promise that dentin/restoration bond strengths will improve in future.

Jacques E, Nor J (1997)[43] suggested that a shorter etching time for dentin of primary teeth might result in a thinner hybrid layer with more complete penetration of resin. He suggested the time for conditioning primary teeth dentin should be approximately 50% less than the time recommended for permanent tooth.

de Araujo FB, Garcia – Godoy F, Issao M (1997)[44] showed that current generation of adhesive systems routinely reported lower bond strengths to primary than to permanent dentin.

Hotz et al (1997)[45] reported that shear and tensile bond strengths for conventional glass ionomer cements are uniformly low, typically in the ranges of 3-5 MPa.

el-Kalla I H, Garcia Godoy F (1998)[46] showed that total etch adhesives have revealed similar bond strengths to both types of dentin.

Olmez et al (1998)[47] reported that many of the current generation of dentin adhesives depend on the permeation of hydrophilic resin into chemically conditioned dentin. Resin retention is achieved by infiltrating hydrophilic monomers into the demineralized dentin to form a resin – collagen hybrid. Formation of this hybrid layer of dentin and resin is thought to be the primary bonding mechanism of most current adhesive systems. Bond strengths are generally lower when the bonding agent does not form a hybrid layer.

Sumikawa et al (1999)[48] concluded that the numerical density of tubules in primary teeth is greater than that of permanent teeth. This decrease in solid dentin may cause the significant differences in bond strengths that normally occur. Primary tooth dentin also has larger tubule diameters with peritubular dentin at least as thick as permanent dentin. With acid etching, there may be less solid dentin available for bonding thus leading to a decrease in bond strength relative to that of permanent teeth.

Meehan P M et al (1999)[49] conducted a study to determine the in-vitro shear bond strength and location of bond failure with two light cured glass ionomer resin systems and to compare them with a composite resin. They concluded that even though new generation of resin modified GICs showed improved bond strength over conventional glass ionomer cement adhesives, they do not appear to provide sufficient shear bond strength when compared to composite resin.

Bishara E S et al (2000)[50] conducted a study to determine the effects of increasing the light cure time on the initial bond strength of a resin modified glass ionomer adhesive. Results showed that the resin modified glass ionomer adhesive has a significantly lower bond strength in the first half an hour after bonding when compared to a conventional resin adhesive.

Jeremy Knox et al (2000)[51] conducted a study to determine the resilience, glass transition temperature, ultimate flexural strength and penetration coefficient of three composite adhesives and a resin modified glass ionomer cement . Results showed that the flexural strength and penetration coefficient of the resin modified glass ionomer cement was less than that of the composite resins.

Owens et al (2000)[52] evaluated the shear bond strength and site of bond failure for two visible light cured composites and a resin modified glass ionomer cement. Results showed that the shear bond strength of resin modified glass ionomer cement was significantly lower than the resin composites.

Cunha (2000)[53] related the advantages and disadvantages about the use of composite resins in primary molars and concluded that to achieve better results, one must carefully select the teeth, choose suitable resin and respect the recognized technique.

Agostini F G et al (2001)[54] reported that due to reduced mineral content of primary dentin compared to permanent dentin, a different effect of acid conditioning has been suggested as a reason for lower bond strengths.

Asakawa et al (2001)[55] showed that bond strength to primary tooth dentin is similar to permanent tooth dentin.

Peutzfeldt A, Vigild M (2001)[56] suggested that, since the etch / prime / bond adhesives require multiple applications, there are numerous opportunities for errors to occur. Therefore, manufacturers have attempted to simplify the systems, and many have developed so called "One Bottle" systems. While these still require etching as the first step, the primer and bonding functions are combined into a single selection, hence, the term "One Bottle". Over the last several years, these products including familiar ones such as Prime and Bond NT (Dentsply Caulk), Optibond Solo (Kerr) and Single Bond (3M ESPE) have been the most widely used adhesives.

Edward J. Swift (2002)[57] reported that when dentin is etched, the surface is depleted of the hydroxyapatite crystals that support the collagen framework. Thus, etching leaves a porous, collagen rich surface that can collapse if dried, limiting penetration of resins applied to that surface. In a moist bonding technique, the surface is not dried after etching and rinsing, and therefore, the collagen remains in position and behaves almost as a sponge. The acetone/ethanol solvent displaces water and carries the resins into the collagen.

Franklin, Garcia – Godoy and Kevin J Donly (2002)[58] evaluated adhesives and resins in primary and permanent teeth conducted in vitro. These in vitro studies show that bond strength and micro-morphological adaptation to enamel and dentin is basically similar for primary and permanent teeth.

Franklin, Garcia – Godoy and Kevin J Donly (2002)[58] has reported that either gel or liquid agents are available for etching the enamel. The gel etchant is more convenient because it is clearly seen during placement and after rinsing, producing similar etching effects of the liquids.

MATERIALS AND METHODS

ARMAMENTARIUM:

- ***Materials used in the study:***

a) Fuji IX (GC Asia)

Powder

90% fluro-alumino silicate glass.

5% polyacrylic acid powder

Liquid

40% polyacrylic acid

10% polybasic carboxylic acid

b) Fuji II LC (GC Asia)

Powder

100% fluoro – alumino silicate glass.

Liquid

50% polyacrylic acid

15% 2–hydroxyethylmethacrylate (HEMA) and initiator.

c) Filtek Z-250 (3M ESPE)

BIS-GMA

UDMA

BIS-EMA

Zirconia/Silica

d) Dentin Conditioner (GC International)

10% polyacrylic acid

e) Total Etch (Ivoclar- Vivadent)

37% Orthophosphoric acid

Silicon dioxide

Pigments

f) Adper Single Bond 2 Adhesive (3M ESPE)

Vitrebond co-polymer

Water/Ethanol

Nanofiller particles.

- ***Equipments used in the study:***

a) Universal Testing Machine (Lloyd Instruments UK)

b) Light Cure Unit(Q-Lux)

c) Straight Handpiece; SDE – H35L: NO- 803202.

- ***Instruments and materials used in the study:***

a) Agate Spatula

b) Mixing pad

c) Tweezer

d) 320 grit silicon carbide paper

e) Diamond Saw

f) Plastic Matrix

g) Pink Acrylic (DPI-RR Cold Cure Powder and Liquid, Mumbai.)

h) 0.9% w/v Normal Saline (Baxter India Pvt.Ltd, Tamil Nadu)

i) Pumice

j) Gloves

k) Mouth mask

METHOD

90 extracted human maxillary and mandibular primary molars of both sexes were used in this study which was carried out in the out patient clinic, Department of Pedodontics and Preventive Dentistry, Saveetha Institute of Medical and Technical Sciences, Chennai.

Tooth Selection Criteria[59]

- Caries free sound mandibular 1st primary molars obtained from serial extraction (8-10 years)
- Caries free sound teeth extracted due to pre- shedding mobility:-

  Maxillary 1st primary molars (10-11 years)

  Maxillary 2nd primary molars (10-12 years)

  Mandibular 1st primary molars (10-12 years)

  Mandibular 2nd primary molars (11-12 years)

Following extraction the teeth were thoroughly rinsed and stored in thymol. Then these teeth were washed with pumice and stored in normal saline[14]. Then the teeth were embedded in self cure acrylic resin to provide a base for testing, so that the buccal surfaces were parallel to the acrylic resin block surface. The buccal surfaces of the teeth were then cut by a low speed diamond saw, until a clean dentin surface was exposed. The prepared dentin specimens were polished using a 320 grit silicon carbide abrasive paper.

The specimens were randomly assigned to 3 groups of 30 teeth each.

Groups

- **Group I :** Teeth restored with **Fuji IX** (Glass ionomer)

The dentinal surface in this group was conditioned for 20 seconds with a solution of 10% polyacrylic acid (Dentin conditioner; GC International). Next, the surface was washed with water spray for a few seconds, and blotted with sponge taking care not to dessicate the dentin. After this, a plastic matrix formed (2mm high, internal diameter of 3mm) was placed perpendicular to the conditioned dentinal surface. Then the powder and the liquid component of Fuji IX was mixed and loaded into the plastic matrix using a plastic instrument. After setting of the cement, the plastic matrix was removed. [60]

- **Group II :** teeth restored with **Fuji II LC** (Resin Modified Glass Ionomer)

The dentin surface was conditioned with a GC dentin conditioner for 20 seconds. Then the surface was rinsed thoroughly with water, and dried by blotting with sponge. Next the powder and the liquid component of Fuji II LC was mixed and transferred on to the plastic matrix and light cured for 20 seconds. Then the plastic matrix was removed. [61]

- **Group III :** teeth restored with **Filtek Z 250** (Composite Resin)

The dentinal surface in this group was etched for 15 seconds with Total Etch gel (Ivoclar- Vivadent). The surface was then rinsed with water, and blotted with sponge. The bonding agent was applied and cured for 10 seconds, followed by placing of Filtek Z-250 into the plastic matrix and cured for 20 seconds. After the curing, the plastic matrix was removed. [62]

The specimens in all the 3 groups were stored in normal saline for 24 hours at room temperature.[14]

Shear bond strength of all groups were measured using a Universal testing machine. A chisel shaped rod was aligned, immediately adjacent to the flat dentinal surface in close proximity to the bonded restorative material. A cross head speed of 0.5mm/min was used to debond the material. The shear bond strength was then calculated in Mega Pascal Units (MPa). Results were statistically evaluated using multiple range Turkey's HSD type test, and One Way ANOVA was used to calculate the p-value.

RESULTS

The conventional glass – ionomer Fuji IX GP showed the lowest mean shear bond strength 3.19 ± 0.73 and the composite resin Filtek Z 250 showed the highest mean shear bond strength 15.94 ± 1.71 MPa while the mean shear bond strength of Fuji II LC was 8.53 ± 0.78 MPa.

Statistical Analysis

Mean and standard deviation were estimated from the sample for each study group. Mean values were compared among groups by One-way ANOVA followed by Turkey – HSD procedure.

In the present study, $p<0.05$ was considered as the level of significance.

Table 1 shows the shear bond strength in MPa of group I, Group II and group III.

Table 2 shows that the mean value in Group III (15.94 ± 1.71) was significantly higher than the mean values in Group I (3.19 ± 0.73) and in Group II (8.53 ± 0.78) ($P<0.05$). Further, the mean value in Group II was significantly higher than the mean value in group I ($P<0.05$).

Shear Bond Strength (MPa) of Group I, Group II and Group III

TABLE.1

Sample.No. (n)	Group I	Group II	Group III
1.	2.75	6.51	17.10
2.	1.97	8.38	16.89
3.	2.32	7.99	17.51
4.	3.71	8.51	15.86
5.	2.83	8.54	15.65
6.	2.15	8.99	15.77
7.	2.20	7.87	13.13
8.	2.55	7.84	16.19
9.	3.53	8.09	17.97
10.	3.14	9.03	16.35
11.	3.21	8.95	15.56
12.	2.39	9.15	16.99
13.	2.45	8.89	17.15
14.	2.41	8.84	17.10
15.	2.32	9.83	17.13
16.	2.95	9.71	17.81
17.	3.99	8.81	15.54
18.	2.89	7.53	14.32

19.	3.97	8.38	10.99
20.	3.98	8.52	16.71
21.	3.94	8.96	13.55
22.	2.97	8.98	17.18
23.	3.91	8.54	16.85
24.	4.01	8.65	17.10
25.	3.98	9.10	17.90
26.	3.94	9.08	15.40
27.	3.93	9.15	13.35
28.	2.89	8.88	14.84
29.	4.12	6.34	17.10
30.	4.15	7.88	13.15

Mean and Standard Deviation (SD) for Shear Bond Strength of Group I, Group II and Group III

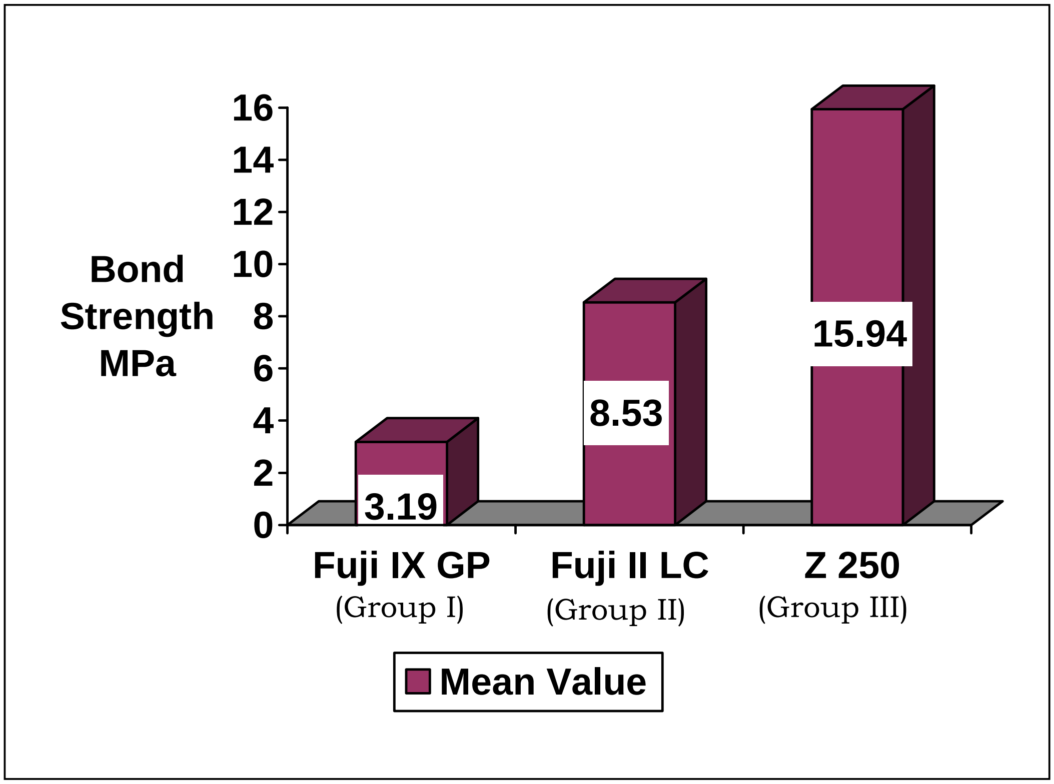
<u>TABLE.2</u>

Group	N	Mean ± SD	P value*	Significant groups at 5% level #
1	30	3.19 ± 0.73	< 0.05 (Sig)	III Vs I, III Vs II II Vs I
2	30	8.53 ± 0.78		
3	30	15.94 ± 1.71		

* One-way ANOVA was used to calculate the p-value

\# Multiple range test by Turkey – HSD procedure was employed to identify the significant groups at 5% level.

MEAN SHEAR BOND STRENGTH OF 3 GROUPS



DISCUSSION

The use of glass ionomer materials in operative dentistry has gradually increased during the last decade as a result of improvement in the materials themselves, as well as changes in restorative techniques. Other factors include a greater demand for esthetic restorations, and the current debate on the amalgam issue ***(Graham J Mount et al 2003)***[63].

Glass ionomer restorations are indicated for deciduous teeth for the restoration of stress – bearing occlusal and proximal restorations.

The adverse effect on the physical and mechanical properties of the earlier type of auto-cure glass ionomer arising from premature exposure to water, or following prolonged dehydration, has been well documented. Immersion in an aqueous environment leads to water absorption and erosion, and dehydration causes crack formation ***(Qvist V et al 1997)***[64]. Both problems adversely affect the strength, as well as the translucency, leading to loss of esthetics in the restoration.

Exposing the newly placed glass ionomer to an aqueous environment too soon after placement is likely to disturb both the water balance as well as the setting reaction. Correlations between early exposure to water and poor clinical performance, inferior translucency, lower compressive strength, and reduced degree of hydration of the set matrix have all been reported ***(Mount GJ 1997)[65].***

Fuji IX GP the material used in this study is an improved auto-curing glass ionomer restorative material that has recently introduced to market. It sets by the conventional acid –base reaction, but shows improved physical / mechanical properties over the earlier type of glass ionomer. Modifications to the glass particle size and size distribution as well as changes to the surface reactivity, have given the new material a more rapid setting reaction, less sensitivity to early changes in the water balance, and lower solubility in oral fluids after setting ***(Croll TP 1998)[66].***

A study by ***John Rutar, Lyn Mcallan and Martin J Tyas (2000)[60]*** have shown that Fuji IX GP can be used as viable restorative material for a period more than 2 years. The tensile and compressive strength of Fuji IX GP was found to be higher than Fuji II. All these reasons were taken into account for selecting this material in the present study.

The composition of the glass ionomer is generally calcium sodium fluoroalumino silicate glass with the composition that is typically high in aluminium and fluoride with significant amounts of calcium sodium and silica. The liquid is polyacrylic acid or alternatively polyacyrlic acid / itaconic acid copolymer or polyacrylic – maleic acid copolymers. The itaconic acid unit and the maleic acid unit in the chain have two carboxyl units and so they are intrinsically more acidic and therefore they provide a greater degree of reactivity to the liquid as well as a lower pH. Another reason for incorporating itaconic or maleic acid in the polymer chain is to produce a more fluid liquid, since they confer irregularities in the chain that minimize the normal tendency of polyacrylic acid chains to become entangled by hydrogen bonding, which represents itself as an increase in viscosity of the liquid ***(Dennis C Smith 1992)***[67].

As shown by ***Wilson and McLean (1988)***[68], the set cement contains the unreacted glass particles surrounded by a layer of ion – depleted hydrogel bonded together by a matrix containing aluminum, calcium and sodium polycarboxylates. The consequence of this matrix structure is that the hydration, leaching and dissolution properties of the cement are very sensitive to the environment, especially in the early phases of setting when the strength is low. A major problem in this regard is the effect of loss or gain of moisture. The access of water to the freshly set cement will tend to cause softening and breakup of the surface of the cement, whereas exposure to low humidity conditions will cause shrinkage with crazing. This could be a reason why the glass ionomer (Fuji IX GP) showed the least shear bond strength as it was immersed in saline for 24 hours, after the restoration was mounted on the dentinal surface.

Another aspect of setting that may considerably affect bond strength is the shrinkage that occurs on setting.

Most tensile or shear bond strength tests of the bond strength of glass ionomer cements to dentin indicate that bond strength much above 5- 6 MPa are seldom achieved ***(Davidson, Van Zeghbroek and Feilzer 1991)[69].***

In other studies ***(Hotz et al 1977)[45]***, similar results of shear bond strengths of values ranging from 3-5 MPa was found. These findings were similar to the present study.

The dentin conditioner used in this study is GC dentin conditioner (GC International), which is a mild polyacrylic acid

(10%) solution designed to remove the dentinal smear layer and to condition the dentin, thus enhancing the bond between glass ionomer cement and the dentin. It's deep blue tint and thin viscosity allows for easy placement and visibility on the tooth surface.[61]

In an in vivo study by ***Maryon, Tobias and Jakeman (1987)***[70], Polyacrylic acid was used as a dentin conditioner which is in accordance with the present study.

The resin modified glass ionomer used in the study Fuji II LC undergo both the traditional acid based reaction between the glass powder and polyacrylic acid liquid and also a light cured polymerization ***(Mitra SB 1991)***[71].

The powder component contains a fluroalumino silicate glass with a photoactive initiator, and liquid component contains a light – curable polyalkenoic acid. The polyacrylic acid chain of the normal cement liquid has been modified by the incorporation of polymerizable methacrylate groups so that when the two components are mixed, the normal setting reaction proceeds with the formation of a calcium aluminium polycarboxylate gel matrix, and when the system is exposed to light, cross linking occurs through polymerization of the methacrylate groups, with the rapid production of a strong, stable structure ***(Dennis C Smith 1992)[63].***

The rapid development of strength is due to the light curing reaction, since the acid base reaction is much slower, resulting in high, early compressive and diametral tensile strengths. ***(Mitra SB 1991)[71].***

Fuji II LC was selected as a material in this study as it is indicated in primary teeth and very few studies were done on this material especially in primary molars.

Most research indicate the post – extraction time does not significantly effect dentinal bond strength ***(Peddey 1981)[72].***

The effect of storage conditions (media) on dentinal bond strength has also been examined . Commonly reported storage media for extracted teeth include: tap water, distilled water, saline, 10% formalin, 0.1% benzakonium chloride etc ***(AM Diaz et al 1990)[14]***. In accordance with the above study, saline was taken as a storage medium in the present study.

The effect of temperature has also been reported. Extracted teeth have been subjected from 5°C – 60°C **(AM Diaz**

et al 1990)[14]. This corroborated with the present study as the specimens were placed at a temperature of 37 degrees centigrade.

When the tooth structure is worked with rotary tools, cutting debris is smeared over the enamel and dentin surfaces. This plugs the dentin tubules and forms what is known as the smear layer ***(Pashley et al 1984)***[73]***.***

This layer of debris undoubtedly has a great influence on any adhesive bond formed between the cut tooth and the restorative material. It has been suggested that the burnishing action of the cutting instrument locally generates considerable amount of frictional heat and shear forces so that the smear layer becomes attached to the underlying surface in a manner that prevents if from being rinsed off or scrubbed away. ***(Pashley et al 1988)***[73]***.***

The bonding agent used in this study is Adper Single Bond 2 adhesive system (3M ESPE) which is a fast, easy and convenient total etch, single component bonding agent. It contains a moisture tolerant vitrebond co-polymer in a water / ethanol solvent. It has nanofiller particles for higher bonding performance with very low post operative sensitivity. Ethanol/ water based adhesive maintains its shear bond strength overtime to yield an outstanding shelf life[74].

The composite resin used in this study is Filtek Z-250 universal restorative (3M ESPE). It is indicated in direct anterior and posterior restorations in primary and permanent molars, sandwich technique with glass ionomer restorative material , cusp build up etc. it offers less polymerization shrinkage, remarkable wear resistance , excellent fracture toughness and overall strength. Also an increment of 2.5mm of Filtek Z250 needs to be light cured only for 20 seconds[74].

Study done by ***Paloma Dias et al(2001)***[75] to evaluate interfacial micromorphology of direct esthetic restoration bonded to primary and permanent tooth dentin with an adhesive system revealed that the composite resin Filtek Z 250 showed a good interfacial seal when compared to other materials used in both primary and permanent teeth.

Another study by ***T Asakawa et al (2001)***[76] on the efficacy of dentin adhesive revealed a similar result for Filtek Z 250 and Single Bond adhesive in primary and permanent molars.

A Study done by ***SB Mitra, D Wu, BN Holmes (2003)***[74] on the compressive, flexural and diametral strength showed that Filtek Z-250 showed the highest among the other composite resins used in the study like Spectrum TPH, Point 4, Esthet X, and Filtek Z-350.

A study done by ***S Schultz et al(2003)***[74] on the wear of various composite resins showed that Filtek Z- 250 showed very low wear compared to the other products like Heliomolar, Compoglass, Spectrum TPH.

A study by ***Burgess et al***[74] revealed that the volumetric shrinkage of Z-250 was less than various composite resins like Z-100 (3M ESPE), Herculite XRV, Venus, Esthet X.

In the present study the results showed that composite resin had greater shear bond strength when compared to conventional glass ionomer cement which is similar to a study done by ***Klockowski, Davis et al in 1989***[77] who evaluated the bond strength and durability of 3 glass ionomer cements when used as a bonding agent and compared it with a composite resin bonding agent and concluded that the bond strength of the glass ionomer cements are significantly less than the composite resin.

Another result in the present study is that the shear bond strength of resin modified glass ionomer cement is significantly less than the shear bond strength of composite resin which can be corroborated by the findings of ***Maria Franseca Stonddrini et al in 2001***[78] who conducted a study to evaluate the shear bond strength of a composite resin and resin modified glass ionomer cured with two different light curing units. The results showed that the bond strength of the composite resin was significantly higher than that of the resin- modified glass ionomer in all the groups tested.

SUMMARY AND CONCLUSION

The purpose of this study was to determine and compare the shear bond strength of a conventional glass- ionomer cement (Fuji IX), a resin modified glass ionomer cement (Fuji II LC) and a composite resin (Filtek Z-250). Dentin of the buccal surfaces from ninety extracted human primary molars were prepared for shear bond strength testing. The specimens were randomly divided into 3 groups of 30 each. Dentinal surfaces were treated according to the instructions of manufacturers for each material. Each restorative material was placed inside a plastic matrix 2mm high with an internal diameter of 3mm, which was placed perpendicular to dentin surfaces. Shear bond strength was tested using an Universal Testing Machine at crosshead speed of 0.5mm/minute in a compression mode.

Fuji IX showed the lowest mean shear bond strength (3.19 ± 0.73)MPa and the composite resin, Filtek Z-250 showed the highest mean shear bond strength (15.94 ± 1.7)MPa , while the mean shear bond strength of Fuji II LC was (8.53 ± 0.78)MPa which was greater than Fuji IX but less than Z-250 .

ANOVA revealed statistically significant differences in the mean shear bond strength of all groups ($p<0.05$).so it was concluded that composite restorative materials show higher shear bond strength than conventional and resin-modified glass ionomer restorative material in primary molars, but shear bond strength of resin- modified glass ionomer is higher than that of the conventional glass ionomer cement.

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